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ISDN-RELATED DEVELOPMENTS

Expectations for ISDN Service

906C3825 Tokyo HEISEI GANNEN DENKI JOHO KANREN GAKKAI RENGO TAIKAI (1989 Joint Convention Record of Institutes of Electrical and Information Engineers) in Japanese Vol 4, 5-7 Sep 89 pp 45-48

[Article by Takashi Sugino, Nippon Steel Information Communications System Co. (NSICS)]

[Text] 1. **Appearance of ISDN Service**

In 1985, the Electronic Communications Business Law was enacted in Japan. This law decontrolled the country's electrical communication business. Following the liberalization of the business, many newcomers entered into this field to compete with the monopolistic Nippon Telegraph and Telephone Corp. (NTT). As a result, lower service rates and the diversification of communication service have been promoted. However, the liberalization must still be extended further, and it is hoped that a further revitalization of the electrical communication market and the efficiency of the operation of the service will be promoted in the future.

The start of ISDN service represents the most noteworthy development in the field of electrical communication service technology in Japan in recent years. The start of ISDN service marked a shift from analog interface, which has been used in conventional telephone service since the 19th century, to a digital interface for the first time.

ISDN service was initiated after a lengthy period of preparation. The ISDN service is expected to usher in a new era in communication network technology, and it is believed that this technology will greatly affect the country's communication service. History proves that the appearance of a new civilization (hardware) generates a new culture (software). Regarding the ISDN, industry watchers are interested to see what effects the ISDN will have on the country's electrical communications; at present, no one can forecast them correctly.

2. Current State of ISDN Service

In April 1988, NTT started ISDN service in Japan when INS NET 64 became operational. In June 1988, the corporation also began operating another ISDN service, ISN NET 1500. The principal features of these services are the capability to transmit large volumes of data and information at high speeds, and intelligence capabilities.

In these services, a free transmission of the control signals is possible between user's terminals and the network, or between those terminals using the D channels. In this sense, the ISDN is more than a new communications channel for the high-speed transmission of signals with greater reliability and lower cost, for it also provides an intelligent service with added values (at no extra cost).

3. NSICS's Trial of NS-INS Service

(1) Network for Corporate Information Communication

For business corporations, information ranks fourth among important management resources, the first three being manpower, materials and money. It is believed that the Japan steel industry somehow managed to escape the recent business crisis thanks to a growth in domestic demand. However, from a long-term point of view, the industry will have to strengthen its business foundations further to deal with sagging international competitiveness and structural changes in the supply and demand situation. Under these circumstances, Nippon Steel Corp. in February 1987 adopted a policy aimed at diversifying its business, and ever since, the corporation has been actively branching out into new businesses. The corporation views information communications as vital for maintaining its wide-ranging business activities. (NSICS came into being in April 1988 as a result of Nippon Steel's information communication system division becoming an independent entity. It offers information communication services to the steel company and to other general customers.)

Under the Electronic Communications Law, those in the first electronic communications business category—which allows them to offer national services using public communications networks—are prohibited from offering a specific service to a specific corporate customer. This makes it impossible for them to act promptly to offer a service based on a new communications technology to customers. To deal with this, it becomes necessary for a company to have its own in-house information communications network in order to keep its communications ability at the most efficient state. During the past few years, the domestic environment surrounding the electronic communications industry has changed considerably because of a further decontrol of the industry, and it has now become possible to build such an in-house network economically as well as technologically.

In May 1987, Nippon Steel started the operation of an in-house information communications system designated NS-INS.[1] Its goal was to strengthen the company's sophisticated information communications capability, which is vital if the company is to survive competition in the highly information-oriented society of the future. Ever since, the company has added new information communications services to meet new demands.

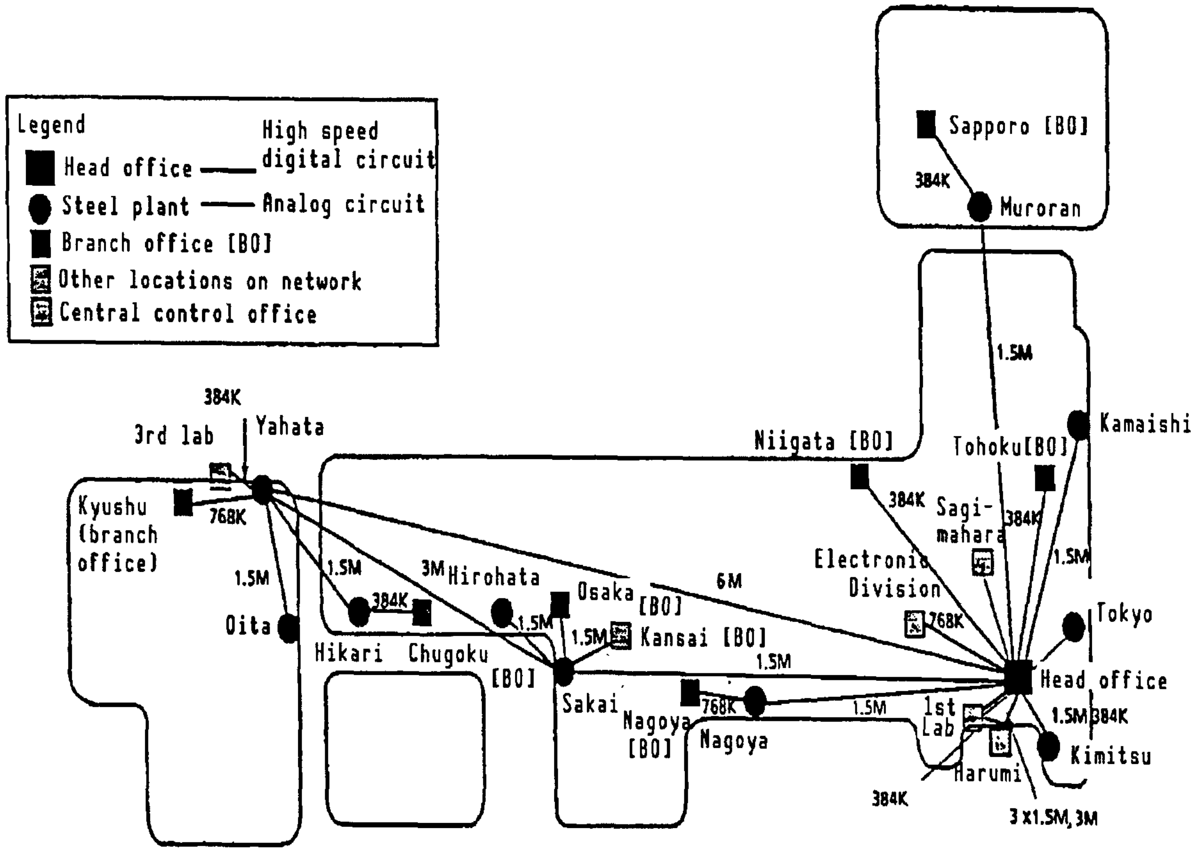
(2) Increase of Service Function

The operation of the NS-INS service began in May 1987. The communications network was built, taking into consideration the possible trends in domestic information communications technology 5 or 6 years ahead, to achieve the following three goals: 1) realization of the Digital 1 link; 2) standardization of equipment interface; and 3) improving reliability.

In parallel with the efforts to realize these goals: the function of NS-INS has been expanded sequentially as described in the following:

1. Toll dial service (telephone, facsimile): started in May 1987
2. Voice, facsimile mail service: started in May 1987
3. Personal computer communications service: started in June 1987
4. Data communications service: started in October 1987
5. TV conference service: started in February 1988
6. High-speed G4 facsimile service: started in February 1988
7. Resale of communications lines operated by other firms: started in March 1989.

(3) NS-INS Networks Being Operated Currently



(4) Future Plans

The following two functions are expected to be offered on the NS-INS network in the future.

1) Packet Exchange Service Operated by NSICS

Judging from the traffic pattern in our company's data communications service, it is believed that, in terms of cost, point-to-point connections are better under the present circumstances. The timing for the start of the exchange service will be determined by observing future changes in the volume of traffic.

2) Private ISDN Service

NS-INS is designed for realizing Digital 1 Link, and the network adopts the No 7 common-line signal scheme. Currently, the line is being used for cutting the time needed for connection substantially, for notifying the addresser's numbers, and for camp-on and forwarding services between offices. However, the interfaces used between the terminals and the PBX now are based mostly on analog, and in this sense the network is short of achieving the Digital 1 Link. And considering the fact that the network is being operated using a scheme that was adopted before the current ISDN recommendation (I interface) came out, the network must be upgraded if it is to offer full-fledged ISDN service. It is expected that the ISDN will revolutionize corporate information communications, and our company is considering starting full-fledged ISDN service using the NS-INS network in the near future. When the service is started, it will be important to ensure conformity between the private ISDN and the public ISDN.

In the following, I will describe the impact that the start of ISDN service will have on corporate information communications.

4. Benefits of Using ISDN in Corporate Information Communication

As described so far, the ISDN has promising future as a communications technology. With regard to the benefits derived from using the ISDN in corporate information communications, the following three points can be considered:

1. The availability of high-speed digital communications service with the rate based on the time of connection (particularly the public ISDN). Even in the private ISDN, it would be possible to apportion the costs for using media other than telephones with the rate calculated on the basis of the time of connection, using the in-house information communications cost apportionment system.

2. The availability of value-added function service.

3. The capability of operating and controlling networks dynamically using the D channel. Judging from the results of experimental operations in the United States, there is little possibility of private citizens in Japan starting to use ISDN service for some time to come.

5. Plan for Introduction of ISDN at Our Company

Some of our company's business departments at the head office are to be moved to a newly constructed building, scheduled for completion in February 1990, and ways to introduce advanced information communications technologies into the new office are currently being investigated.

When splitting the function of a corporation between two separate places, overcoming the inconveniences resulting from the distance between the two offices is most important. In particular, the problem of how to maintain the face-to-face communications that are possible within a single office looms as a significant problem. Already a division of our company has been operating a television conference system[2] using a high-speed digital circuit. However, there is now a need for the introduction of a line-switched service, which allows people located in different places to discuss their work through desk-top TV telephones sitting at their desks. The ISDN will make this possible. The delay in standardizing video signal compression and the coding technique for the transmission of TV phone image signals and incompatibilities among terminals produced by different makers have prevented our company from going ahead with the introduction of such a switching system.

6. What Is Hoped of ISDN

(1) ISDN's Application Fields in the Near Future

The ISDN is a new technology and its application fields must be developed through cooperation among vendors, carriers and users.

As for applications in corporate information communications, there are a number of possibilities for the near future, and already a number of domestic companies have announced various uses for the ISDN service. These application fields are: G4 facsimile information transmission, video signal transmission, and the transmission of large document files. As for the facsimile service, information is currently transmitted in monochrome, but in the near future color transmission should become possible. Video signal transmission technology could be used for TV conference systems, TV phones and video databases.

All these applications take advantage of ISDN's digital communications capabilities, i.e., the high-speed transmission of large volumes of data, but do not use the intelligence aspect of the service.

(2) Intelligent Network

The communications described above emphasize the transmission of as much information as possible correctly, and researchers in communications engineering have been making efforts to boost the efficiency of information communications. In the relevant regulatory documents, the term communication is defined as "mediating the communication of others" (exchange and distribution). Ideally, the intermediary (network) should be "transparent," that is, its presence does not pose any problems for users.

In designing future information communications systems, more attention must be paid to preventing deliberate distortions of the contents of the information to be transmitted and leaks of information to unauthorized parties. Future networks will be required to be more flexible in meeting the diversified needs of customers. Telephones with translation capability (from one language into another) represent one such need. So far, users have never considered the possibility that they could play a role in modifying and improving a communications network. In the future, it will become possible for users to have a dialogue with other terminals as well as the network by using the D channel in 2B+D ISDN channels. By taking advantage of this, it would become possible for users to devise a new communications service and have the software installed in the network to make the service possible. The installation of the software may be made either by customers themselves or by carriers. When an open-ended network like this is realized in the ISDN of the future, the network will be more intelligent, and this will make it possible to offer high value-added services to customers.

The ISDN can be described as a communications technology that has the capability of functioning as an intelligent network.

(3) Problems in ISDN Service

Despite its advantages, demand for ISDN service in Japan has been slow. However, considering the fact that a new culture is accepted by society over time after many trials and errors, demand for ISDN service can be expected to increase in the future. In the process, it is important to promote ISDN service under a proper vision to avoid experiencing a major setback in the effort. In view of this, efforts must be made in the following three areas:

•Standardization of Communications Protocols

As described in the preceding section in connection with our company's study on the introduction of TV phones, it is important to develop terminals suitable for use in an ISDN network to promote demand for the network service. At the same time, the network must be able to accommodate terminals produced by any makers if it is to serve as a public digital communications network. In this sense, the standardization of communications protocols is more important for ISDN than it was for analog-based communications.

•Preparation for Coming Age of Multimedia Communications

The regulations being enforced currently were formulated to govern analog-based communications. Therefore, they cannot be applied properly to an ISDN involving multimedia digital communications. In the ISDN, it is nonsense to distinguish between voice information transmission and facsimile data transmission. For this reason, the regulations governing public line-private line connections in voice information transmissions must be abolished.

•Publication of User Applications

In order to develop markets for ISDN service, it is important for the carriers and vendors to actively publicize available applications that can benefit users, and, at the same time, to make efforts to unify such applications.

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2. Furuyama and Hosokawa, "Private TV Conference System at Nippon Steel Corp." Ibid., Vol 14 No 9, 1988.

Prospects for ISDN Technology

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[Article by Tetsuaki Egawa, Nippon Telegraph and Telephone Corp.]

[Text] **Prologue**

Because efforts to standardize ISDN interface have progressed thanks to recent developments in digital communications technologies, commercial ISDN service are beginning to be started in a number of companies around the world. In Japan, a 64-kbps line-switching service using a basic 2B+D access interface that connects Tokyo with Nagoya and Osaka began operating in April 1988. Since then, the network has been extended to other cities, and as of June this year the network covered 56 separate districts across Japan. That same June, a 23B+D primary access interface was added to the network. This made it possible to meet the needs of major customers at the bit rate of 64 kbps and to offer line-switching service at higher speeds of 384 kbps and 1,536 kbps. In the following, I will describe the technologies involved in this ISDN service, including network architecture and system composition. I will also discuss ISDN's impact on network service and the future prospects for ISDN service.

1. Outlines

Next year will mark the 100th anniversary of the start of telephone service in Japan, which began in 1890. The start of ISDN service in Japan came about a century after telephones first began to be used in the company. The ISDN can be regarded as a digital communications network in which the technologies of digital communications relay, digital switching and digital network common line signal transmission—all of which were developed and put into practical application during the 1970s and 1980s—are organically combined in their most advanced states with subscriber's digital line transmission technologies. The start of ISDN service will have a great impact on the future construction of communications networks and the development of indoor ISDN equipment. In the following, I will describe these prospects from a macroscopic perspective.

In conventional telecommunications, separate communications networks are required for the transmission of information having different attributes. However, in the ISDN it becomes possible to transmit various kinds of information over a single network thanks to the introduction of a standardized interface for the network. This could bring economic and other benefits to both network operators and customers. In addition the ISDN is expected to promote structural reforms in communications networks and the modernization of network facilities. With regard to telephone service, digitalization has been promoted for signal transmission and exchange systems primarily for economic reasons. In the ISDN, Digital 1 Link service must be provided. In the ISDN, digitalization must be pushed with the goal of digitalizing the whole network and its related facilities, rather than digitalizing its individual components. In other words, digitalization must be promoted for all fields of ISDN service operation. This requires the introduction of a common-line network for switching signal traffic between the switching offices. In fact, such a common line signal transmission scheme has been widely used in conventional communication networks between trunk exchanges. In the ISDN, this common line scheme must be extended further to the switching on the subscribers' loop. The promotion of the scheme could lead to an expansion of SPC communications networks, and this will make it possible to offer more sophisticated ISDN services. The digitalization of subscribers' lines would also have a significant impact on the overall improvement of ISDN service. The introduction of the basic access interface has made it possible to transmit digital signals over conventional metallic wires, and this has led to a substantial reduction of the per-bit cost of operating subscriber systems. The primary access interface is designed for transmitting signals over optic fibers. If demand for the fiber optic cable-based service increases substantially, it would promote the expansion of the fiber cable lines to subscribers' lines.

Meanwhile, the communication protocols between network and terminals have been improved greatly in compliance with OSI standards. The signal involved has a message-type format and the protocol has the capability of transferring not only line-switching control signals, but also packet information and user-to-user information. With the introduction of the protocol, it has now become possible to implement communications between network and terminals smoothly. In the traditional signals transmission scheme, this relationship is basically that between master and slave. The introduction of the protocol is almost tantamount to an extension of the common-line signal communication scheme currently being used between exchange offices to the terminals. Now it is expected that various kinds of new terminal equipment with more sophisticated functions will appear on the market for use on the ISDN network.

2. Organization of ISDN Network

(1) Interface

After about 10 years of arduous study by CCITT, ISDN's user terminal-network interface was finally standardized last year. Following this, the standard interface for domestic ISDN service in Japan has been decided based on the CCITT recommendations and by selecting the optional parameters suitable to the country. In April 1988, the 2B+D basic access interface was put to commercial use. This was followed by the introduction of the 23B+D primary access interface in June 1989. Now, NTT is offering line switching services at 64 kbps using the basic access and primary access interfaces, and at 384 kbps (H_0) and 1,536 kbps (H_{11}) using the primary access interface. In NTT's network the terminal-network interface is placed at the T interface point in the diagram shown in Figure 1. NTT's network also offers packet switching services through both of the interfaces using B and D channels. Currently, there are not many companies in the world that offer ISDN services covering H_0 as well as H_{11}. As for packet switching service, many of these companies are reportedly intending to start it around 1991. In this respect, Japan is running ahead of these foreign countries in ISDN service. With regard to internetwork interface, CCITT recommends the common-line signal transmission scheme incorporating ISDN user part (ISUP) for line switching, and X.75 interface for packet switching. It is expected that Japan will adopt these interfaces.

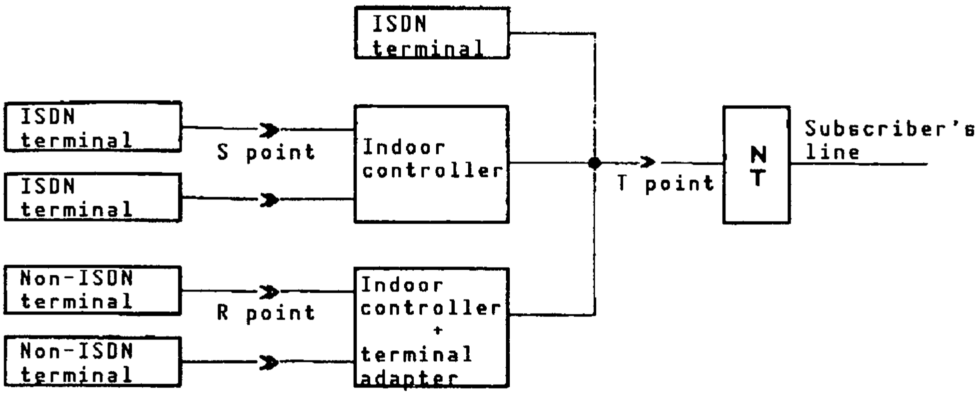
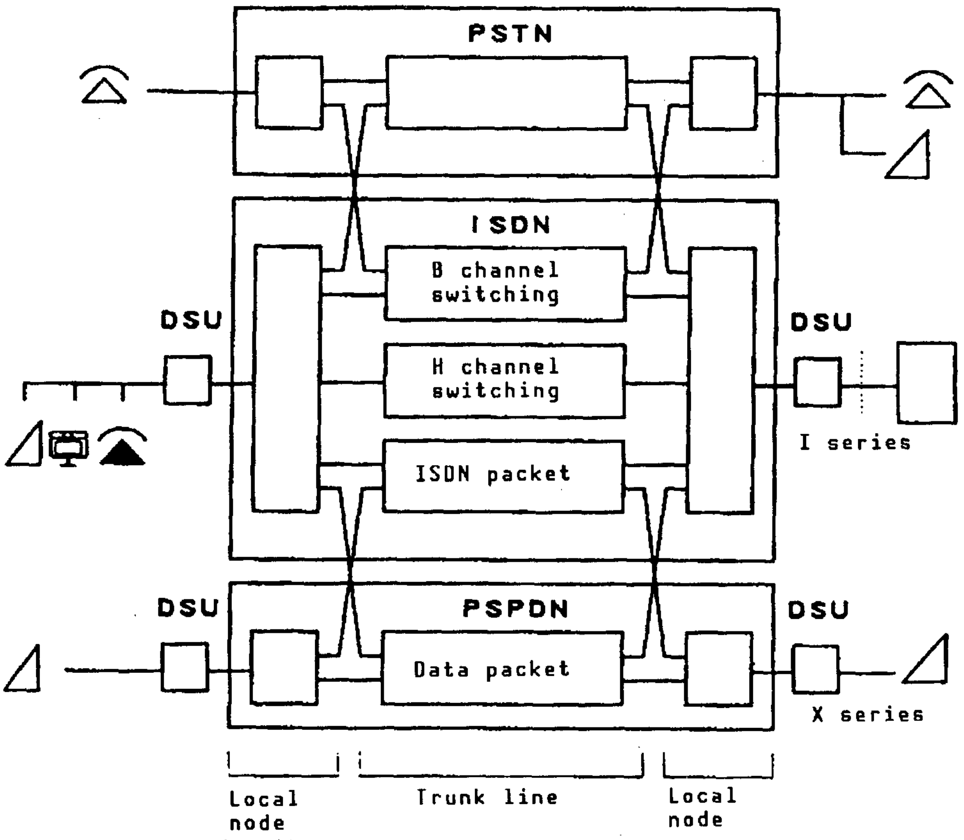


Figure 1. Interface Reference Points on ISDN's User Network

(2) Network Organization

Figure 2 shows a popular example of ISDN circuit organization. Due to the fact that B- as well as H channel switching service and packet switching service is being offered through a single user terminal-network interface, the subscribers' line system takes a uniform hardware configuration combining the functions for these services—at least in delaying with layer 1 and layer 2 transfer processes. In the levels higher than layer 3, various system configurations become available depending on the user's need. As to the trunk line, it is advisable to have separate ones for line switching service and packet switching service, considering the differences in the attributes of the information handled and the signal transmission mode. With regard to line switching on the 64-kbps lines and the H channel for H_0 and H_{11} services, a common line can be used, given the similarity of the technologies involved, if the problems related to multiprocessing are solved. However, a separate line scheme can also be recommended for higher efficiency in switching jobs. In the future, when a wide-band ISDN technology like ATM becomes economically viable it will become possible to execute the switching and the processing for signal transfer using the same interface. There is a strong possibility that wide-band technology will be introduced first in the trunk lines. Meanwhile,



PSTN: Public-switched telephone network
PSPDN: Public-switched packet data network

Figure 2. Organization of ISDN Network

as to relations with existing communications networks, the B channel switching is where there is a possibility of logic sharing. As for the B channel switching system, it can share numbering schemes and signal transmission schemes between offices with existing telephone networks. The digital lines between the offices can also be shared. It would also be advantageous for the voice and other audio-related ISDN services to be made available to subscribers of conventional analog telephone service through a mutual connection of the networks. From what has been described above, the sharing of network resources should become possible, at least at levels higher than the distributing stage of the digital subscribers' line switching system.

(3) ISDN Network Service

Basically, the ISDN's user interface is designed to make the best use of the network as the medium for providing data and information carrier service. For the benefit of customers, ISDN network architecture must be studied by examining every element of the system up to the equipment located on customers' premises. If possible, more time should have been allocated to developing the user interface by having more discussions about what kind of carrier service should be offered and how such a service could be provided. In the actual development process, however, greater emphasis was placed on the technological aspects. Under these circumstances, the need will arise in the future for the present protocols to be modified to include more functions, especially in view of the fact that the protocol can be changed. The present protocols allow exchanges of information between the network and terminals in many different ways. Part of this information is used in the network for switching and other needed processing purposes, though most of it is conveyed to the intended users. Among various kinds of information transmitted over the network, the most important may be the master terminal ID. In conventional networks, the ID includes the information needed for circuit connections and does not include other functions that may be useful to customers. The master terminal ID, once issued, is transmitted to the intended receiving terminal. In the ISDN, the received ID information can be used for various purposes. Table 1 lists the kinds of ISDN services that are either being offered currently or will be offered in the future. In the ISDN, very sophisticated control signals are exchanged between the network and terminals and between terminals. This will allow further progress in providing sophisticated communications services over the network through the user interface. For example, in the old days, in many cases a communications system having information processing capabilities was achieved through the common-line interface between the switching offices. Now, however, it has become possible to obtain such a capability through the ISDN's T interface point, which provides access to a greater number of functions.

3. Network System Organization

The ISDN subscribers' line transmission system can be divided into two primary functions: basic access interface and primary access interface. For the basic access interface, two types of DSU are available: one is for leasing a single 2B+D channel to ordinary customers and the other is for leasing multiple channels to large corporate customers. The former uses conventional metal wire lines to connect with the subscribers, while the latter uses mostly fiber optic cables. On the other hand, in the primary access interface system, the 1.5 M DSU is provided using either fiber optic subscribers' lines or radiowaves as a temporary measure where a fiber optic cable does not exist. In Japan, the specifications for the user network interface are determined on the basis of the various factors at the T interface point. For this reason, these DSUs have various network terminal functions, including turnaround test function.

Turning to the network node, a standard subscriber's node usually consists of an analog telephone line concentrator, an ISDN line concentrator, a 64-kbps distribution system, an H channel distribution system, a packet distribution system and a supervision-test system common to all these systems. Figure 3 shows the organization of D70, NTT's digital subscribers' line switching system. The ISDN line concentrator is made up of I interface subscriber system modules called ISM. ISM serves as the terminal for the subscribers' line transmission system as well as for the subscribers' line signals. ISM has the functions of a line concentrator for the B and H channels, the switching function for the office to which it belongs, and the switching function for packet cells. The B channel switching/distribution system shares system resources with the analog telephone subscribers' line system, and this setup makes it possible to share the 64-kbps ISDN trunk between them. In addition, the switching/distribution system has special functions for connecting the various subscribers' equipment used on the 1XY channel to the ISDN circuits. In the H channel switching/distribution system, ISM becomes necessary when the volume of demand for the service through the system reaches a predetermined level. A subscribers' line packet switching function is included in PHM. The supervision/test functions are contained separately from other function modules in the supervision/test module STM.

Table 1. Kinds of ISDN Services

<table>
<tr><th rowspan="2"></th><th colspan="2">B channel switching</th><th rowspan="2">H channel switching</th></tr>
<tr><th>Voice and audio</th><th>Digital</th></tr>
<tr><td rowspan="1">Services specific to ISDN</td><td colspan="3">• Addresser number notification
• Service rate notification
• Information exchange between users
• Arrival-of-information during communication</td></tr>
<tr><td rowspan="2">Improved versions of existing services</td><td colspan="2">• Transfer of received information
• Call waiting, etc.</td><td></td></tr>
<tr><td>• Communication between third parties, etc.</td><td></td><td></td></tr>
<tr><td rowspan="2">Services also being offered on conventional networks</td><td colspan="3">• Telephone for direct communication, telephone communication by dialing abridged number, service charge notification</td></tr>
<tr><td>• Various value-added telephone services</td><td></td><td></td></tr>
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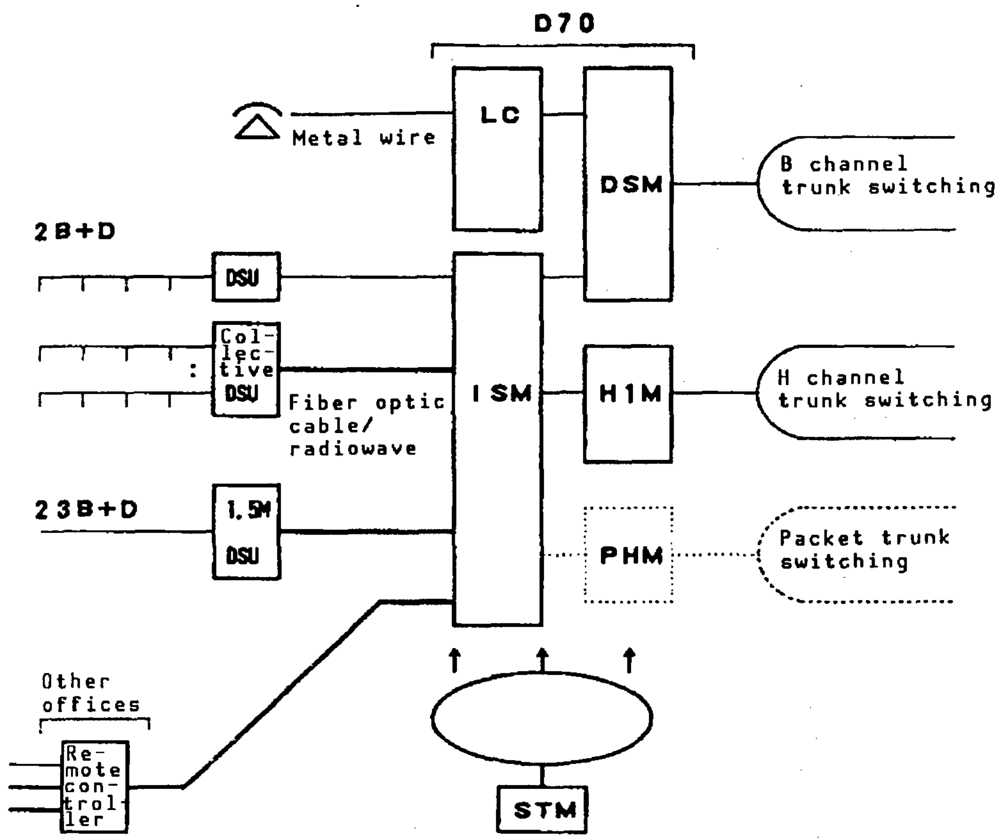

Figure 3. Organization of ISDN Subscribers' System

In the above, I have described the node configuration at a standard ISDN office. For these ISDN offices where demand for the services is not so great, the ISDN node functions to be deployed there should be confined to the essential minimum for economic reasons. One option that is being provided is for a small demand to be handled by a larger office via local multiplex transmission remote terminals (RT). The RT scheme has a low office-to-office transmission efficiency due to the lack of a concentrator facility. However, it can be used where economy of operation is more important than communications efficiency.

4. Current State of ISDN Service in Japan

In April 1988, with 114 initial subscribers, NTT started a 64-kbps line-switching ISDN service connecting Tokyo with Nagoya and Osaka using the basic access interface. Since then, the service area has expanded so that as of June 1989 it covered 56 districts across the country. The number of subscribers, meanwhile, has increased to about 1,700. As the second step, a 64-kbps switching service for larger customers and an H channel switching service at the bit rates of 384 kbps as well as 1.536 Mbps were started using the primary access interface (INS 1500) in June 1989. These new services were begun with 21 initial subscribers.

The rate for the 2B+D channel service is set a bit higher than twice the rate of ordinary telephone service. (The rates for handling packet transmission service have yet to be decided.) The communication rates for a 64-kbps digital call are nearly the same as the rates for ordinary telephone service. Considering that the bit transmission rates attained on an ordinary telephone line are 9.6 kbps at the most, the communication service rate per bit can be as much as 10 times cheaper than the telephone. Meanwhile, the base rates for the primary access interface using INS 1500 are about 20 percent cheaper than subscribing, just for comparison, to 23 separate ordinary telephone channels. As for the ratios of service rates between long-distance communications and local communications, they are 15 to 1 at the bit rate of 384 kbps and 11 to 1 at the bit rate of 1.5 Mbps. This compares with the ratio of 33 to 1 for an ordinary telephone.

5. Problems That Must Be Solved for Popularization of ISDN

A little more than a year has passed since the start of ISDN service in Japan. However, demand for the service is low, even admitting that it takes time for a sophisticated new service to become widely used. Unlike 10 years ago when the DDX service started, we currently have an environment that should encourage the spread of ISDN service. In order to speed up the popularization of ISDN, many more problems must be solved. The first of these problems involves an expansion of the service area. As of the end of FY 1988, the ISDN network covered 29 cities across the country. By the end of the current fiscal year, the network will expand to cover about 130 or so major cities. Almost every city in the country may be linked to the ISDN network within 2 to 3 years. The efforts to develop an RT system must also be stepped up in order to introduce economical ISDN stations with smaller initial investments. The second problem concerns the development of less costly user terminal equipment. Recently, the number of kinds of such equipment has been increasing. However, efforts to develop less expensive equipment comparable to the more economical ISDN communication rates must be stepped up. As for the higher layer protocols between terminals, the work on determining the Japanese version of the standard parameters for using terminal adapters and high-speed G4 facsimile transmission has been completed. One problem with the ISDN protocols is the delay in the formulation of international standards for video signal encoding. The third problem concerns the expansion of the ISDN network to foreign countries. Studies aimed at realizing connections between separate networks at the earliest possible time are underway.

6. Summary

So far in this chapter, I have discussed ISDN network technologies, the current state of the service, its future prospects, and the problems that must be solved to promote the popularization of the service. What has been discussed to this point involves the narrow bandwidth ISDN service that is being offered using the basic access interface as well as the primary access interface. The further popularization of this service could encourage demand for a broader bandwidth ISDN.

Corporate Information Communications Network

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[Article by Daisaku Minato, NEC Information Communication System Department]

[Text] 1. **Introduction**

In recent years information has been attracting increasing attention as the fourth most important corporate resource, after manpower, materials and money. The information coming in incessantly from around the world is increasingly gaining in importance. Under the circumstances, it is becoming vital for business corporations to have an efficient corporate information communications network and to operate it effectively. This is in addition to having the ability to process acquired information using computers. It is believed that such a network will increasingly assume an intelligence power in the future, and this sophisticated capability will be realized by the ISDN.

ISDN service in Japan was started by NTT in April 1988 to provide an expanded multimedia communication network service in more standardized form. Following the start of INS Net 64 services in 1988, NTT added INS Net 1500 service in June 1989 to accelerate the popularization of ISDN service in the country.

In the remainder of this chapter, the ISDN and the corporate information communications networks in Japan will be described.

2. **Current State of Corporate Information Communications Networks**

The function of information in a corporation is to make it possible for the corporation to use various corporate resources organically (Figure 1). To promote this, it is necessary to accelerate coordination between the processing of information by computers and the distribution of processed information using a communications network.

It is only about 4 years since the effort to construct an information communications network that would allow the connection of sophisticated information processing systems started in Japan. This effort followed the start of NTT's high-speed digital line switching service in 1984. Many domestic corporations are now in the process of constructing their own information networks. The high-speed digital lines operated by NTT and NCC (new common carriers) are currently being used by about 1,000 domestic corporations, and the total number of channels being used is about 10,000. Most of them are being used as trunks for building integrated digital networks. Such networks are being used primarily as in-house telephone networks, while some 20-30 percent are being used for nontelephonic communications including data communications, image signal communications in CAD and CAE, and video signal communications for TV conferencing. These nontelephonic media are being operated independently from each other using

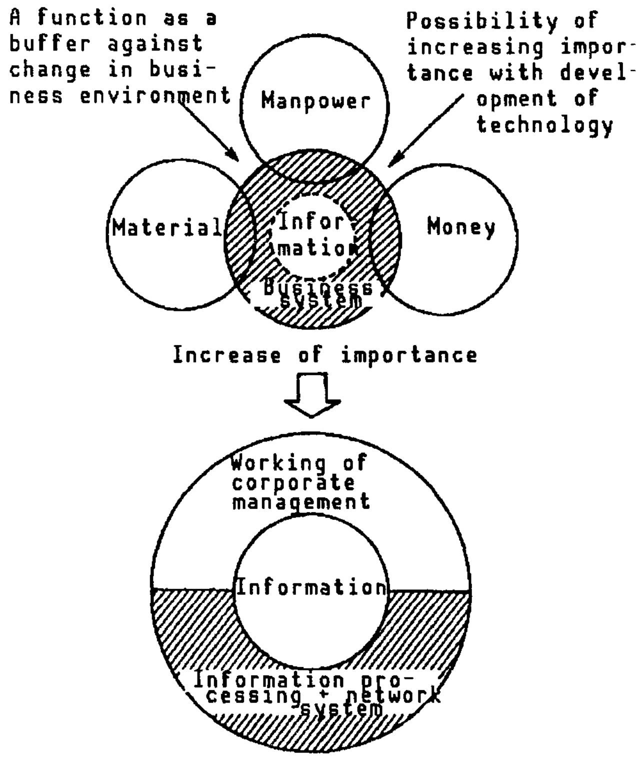


Figure 1. Intersection of Information Processing Capability and Communications Network in Corporate Business System

common high-speed digital lines. It would take several years for these existing networks to be modified into the ideal form of corporate information communications networks. The current situation could be regarded as the first stage in an effort to create an appropriate corporate information communications network, engaging in building basic digital networks.

3. Future Corporate Information Communications Networks

Corporate customers want the following to be realized in the corporate information communications networks of the future:

(1) Expansion of Network

• Expansion and improvement of branch networks following the digitalization of the trunk networks (for example, the sales outlet network in a manufacturing industry and the branch office network in a financial industry).

• Sharing of networks (for example, joint utilization with subsidiaries or business partners, and mutual connections among separate networks).

• Expansion of networks to foreign countries to meet the globalization of business (for example, the international packet switching network by the domestic financial industry and the overseas CAD network by the domestic manufacturing industry).

(2) Promotion of Intelligent Capability

• Promotion of value-added information communications (for example, facsimile mail simultaneous reporting and telephone-facsimile media switching as the functions of computer terminals).

• Realization of network applications (for example, a hotel front desk telephone capable of flashing the information about the caller staying at the hotel, or an automatic telephone call forwarding system).

• Realization of dynamic networking to increase communications line utilization efficiency (for example, the assignment of a communications channel suitable for a specific communications need and a function for the automatic detour of congested channels).

(3) Opening of Networks to More Customers

• Promotion of the construction of integrated multimedia communications networks (for example, telephone service combined with the capability of transmitting handwritten messages, the transmission of still images accompanied by voice explanations, and an automatic dialing telephone with a telephone directory number searching function).

• Selective utilization of communications lines operated by different carriers (for example, automatic selection of the least costly communications line, making the system work by using either a radiowave link or satellite communications channel, error correcting algorithms, the response monitoring scheme, etc.).

• Creation of a network that does not harm a multivendor environment (for example, support of standard protocols and improvement of protocol conversion capability).

4. Basic Concept for Introduction of ISDN Into Corporate Information Communications Networks

To meet the needs of corporate customers for advanced corporate information communications network functions, it is important to upgrade the existing corporate digital communications networks to transform them into in-house ISDNs or private ISDN. An in-house ISDN is required to have not only an advanced system function and performance, but also the flexibility to accommodate the demands of customers.

Figure 3 shows an organizational scheme for an in-house ISDN. The in-house ISDN is an integrated digital network constructed around a digital PBX, in which data and voice as well as image signals can be transmitted. For efficient operation, an in-house ISDN network must be linked organically to a public ISDN network like NTT's INS Net service.

The following are the conditions required for an in-house ISDN network:
1) Integrated multimedia communications network capable of handling data and

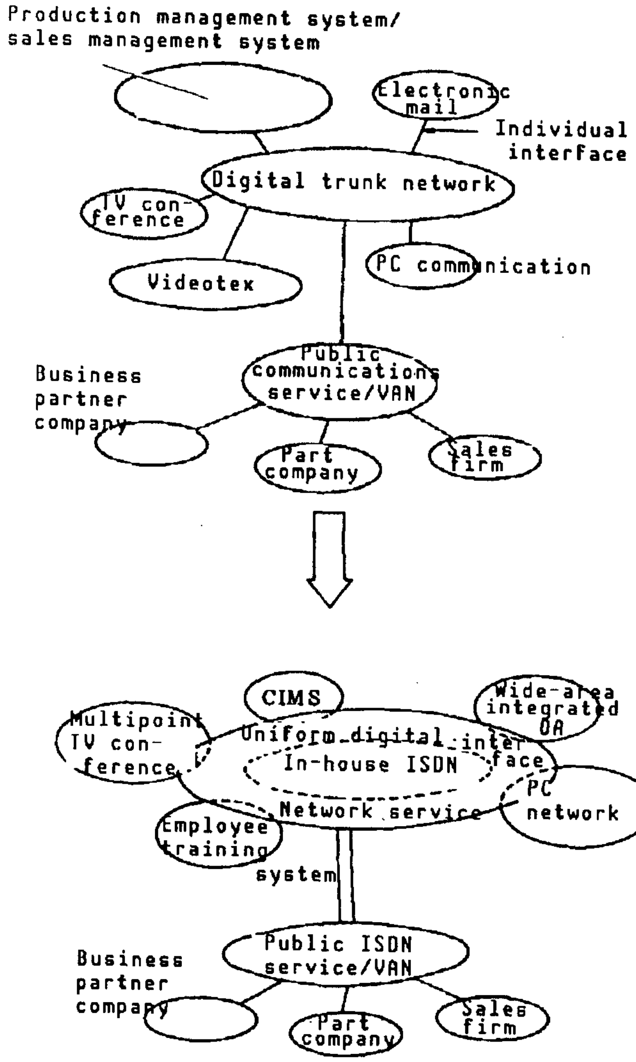
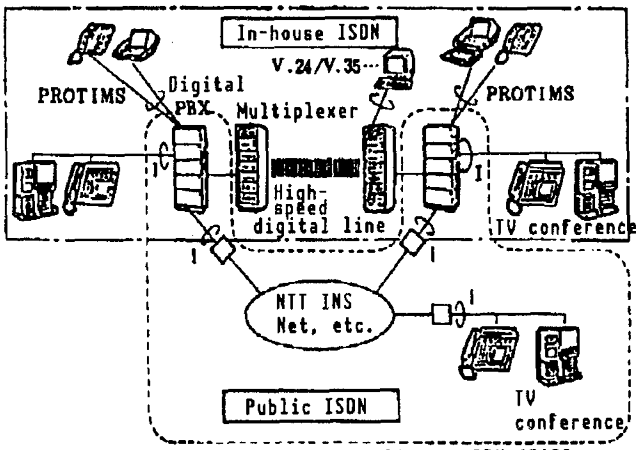


Figure 2. Concept of ISDN Corporate Information Communications Network

voice as well as image signals; 2) terminal-to-terminal complete digitalization; 3) standardization of user access interface; 4) increased intelligence of network (flexible and sophisticated communications service); 5) mutual connections with other networks while ensuring no degradation of service quality (public ISDN, other private ISDN networks, satellite communications network, international communications network, etc.); and 6) rigid network management.

5. Important Points in Actual Utilization of Corporate Information Communications Network

In the preceding sections of this chapter I have described the current situation of corporate information communications networks in Japan, the expectations of corporate customers regarding ISDN service and other basic things about ISDN. In this section, I will describe the important points



PROTIMS : Digital interface peculiar to PBX (Differs from maker to maker)
I : ISDN interface in CCITT's I series recommendations
V.24/V.35···: Existing interface for data communications

Figure 3. Example of Organization of In-House ISDN Network

regarding the use of corporate information communications networks connected to NTT's INS Net 64 and 1500 from two perspectives.

(1) Economical communications using the INS Net: 1) comparison of line utilization charge; and 2) efficient use of INS Net when communications traffic is heavy.

(2) Utilization of the high-speed capability of INS Net.

(1) Economical Communications Using INS Net

1) Comparison of Line Utilization Charge

Table 1 shows a comparison of the monthly communications line utilization charge between 23 ordinary telephone service lines and using the INS Net 1500 via the 23B+D primary access interface.

Table 1. Comparison of Monthly Communications Line Utilization Charge (Unit: ¥)

Ordinary telephone line	INS Net 1500
2,350 x 23 = 54,050	45,000

As shown in the table, using INS Net 1500 results in a savings of ¥9,050 per month compared to using 23 ordinary telephone channels. Figure 4 shows the results of another comparison of the utilization charge between the two different communications lines.

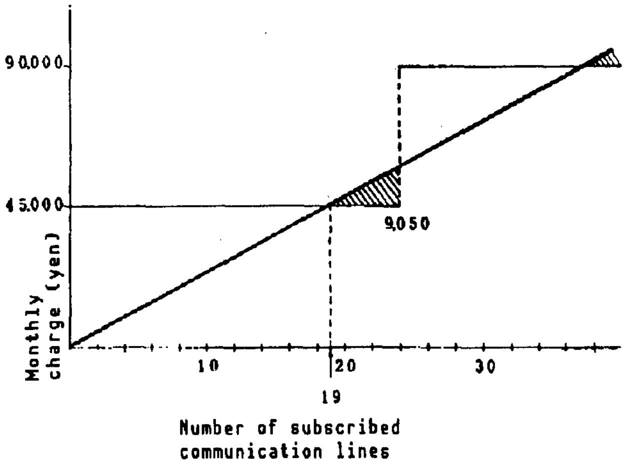


Figure 4. Comparison of Monthly Line Utilization Charge Between Ordinary Telephone Line and INS Net 1500

2) Efficient Use of INS Net When Communications Traffic Is Heavy

It is possible to create and operate an in-house communications network economically by limiting the available communications capacity in the leased lines to the minimum and by using INS Net when the volume of communications surpasses its capacity.

The INS Net also can be used when trouble occurs in the leased lines.

Figure 5 shows a distribution pattern for communications during business hours, and Figure 6 illustrates the economic benefits of making appropriate use of the INS Net.

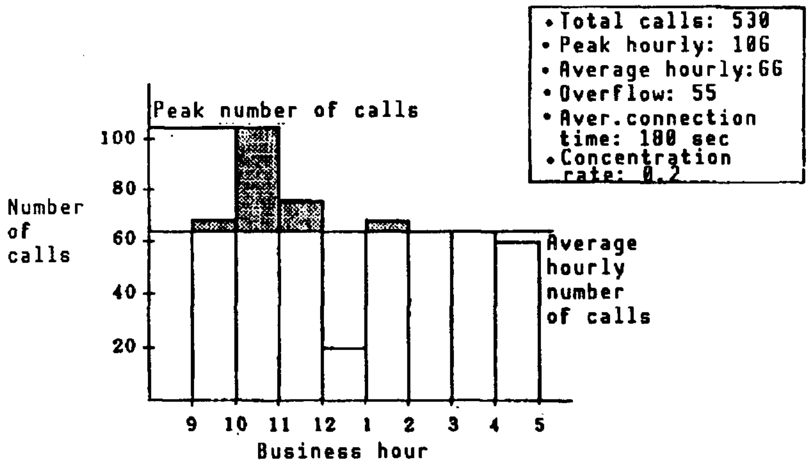
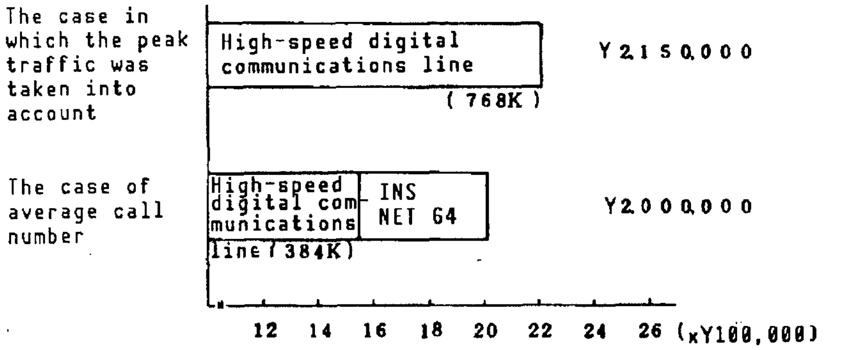


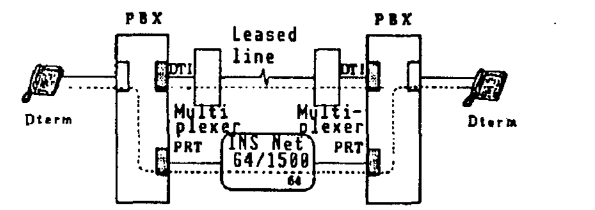
Figure 5. Distribution Pattern of Calls Made by a Company During Business Hours (Example)

Figure 7 represents an example of using the INS Net to cope with a temporary surge in communications volume in an in-house corporate communications network.



Note: The monthly communications line utilization charge was calculated by excluding the amount of the basic rates and based on 25 work days per month

Figure 6. Economic Benefits of Using INS Net 64 To Handle Heavy Communications Traffic

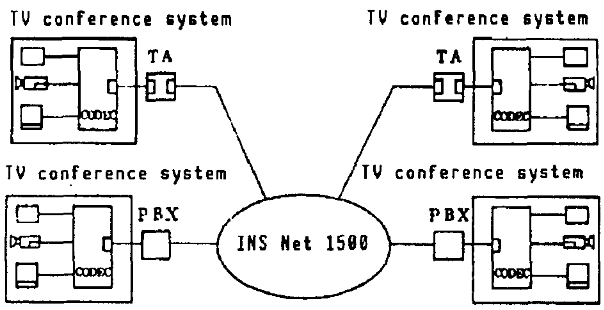


DTI: Digital trunk interface PRT: Primary rate access trunk

Figure 7. Example of Using INS Net 1500 To Cope With Heavy Communications Traffic

(2) Utilization of the High-Speed Capability of INS Net

Without leasing a high-speed digital communications line, it is possible to implement a TV conference system or a high-speed information communications system using INS Net 1500's H_0 channel (384 kbps) and the H_1 channel (1.5 Mbps) through the primary access interface (Figures 8 and 9).



Merit
- TV conference can be made with any other party (parties) connected to the INS Net.
- Connection to INS Net 1500 H_0 allows subscribers to access increased number of destinations in addition to ones covered by leased conventional high-speed digital communications line.

Figure 8. TV Conference System Via INS Net 1500

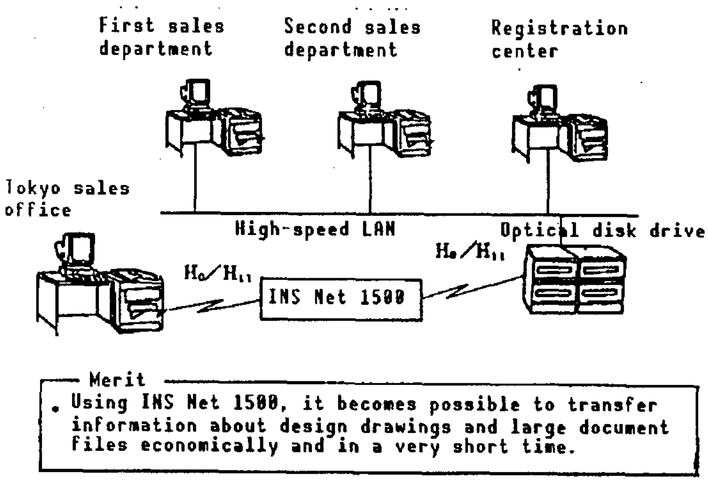
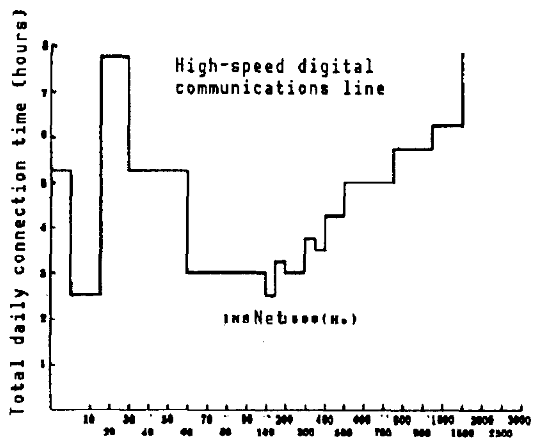


Figure 9. High-Speed Information Transfer Service System

Figure 10 shows a comparison of the line utilization charge between the high-speed digital communications line and the INS Net 1500's H_0 channel. Figure 11 compares the high-speed digital line with INS Net 1500's H_1 channel. When the destinations of a communication are located within a 20~30 km radius, it is considered that using the INS Net H_0 channel is more economical than using a leased high-speed digital line.

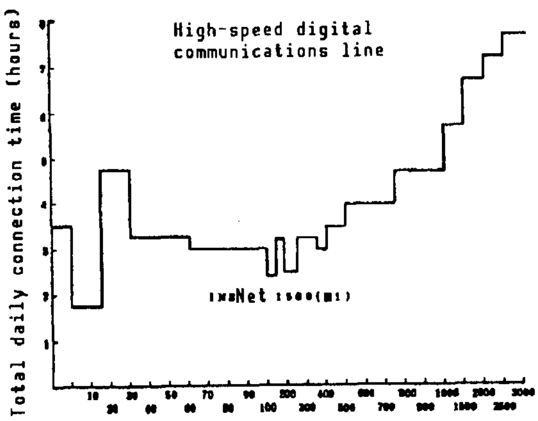


Same area

Distance to communication destination (km)

The graph represents the area of lower line utilization charge when the two different communications lines were used independently for 20 business days per month.

Figure 10. Comparison of Monthly Line Utilization Charge Between 386 kbps High-Speed Digital Communications Line and INS Net 1500 H_0 Channel



Same area

Distance to communication destination (km)

The graph represents the area of lower line utilization charge when the two different communications lines were used independently for 20 business days per month.

Figure 11. Comparison of Monthly Line Utilization Charge Between 1.5 Mbps High-Speed Digital Communications Line and INS Net 1500 H_1 Channel

Epilogue

In this chapter I have described the benefits of incorporating ISDN into an in-house corporate information communications network. It is expected that the ISDN will be introduced into an increasing number of corporate information communications networks. Given this prospect, the development of useful ways to employ ISDN and practical ISDN utilization systems would promote the development of corporate information communications networks in Japan.

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ISDN Terminal and Interface

906C3825 Tokyo HEISEI GANNEN DENKI JOHO KANREN GAKKAI RENGO TAIKAI (1989 Joint Convention Record of Institutes of Electrical and Information Engineers) in Japanese Vol 4, 5-7 Sep 89 pp 57-60

[Article by Nao Usami, Fujitsu Ltd.]

[Text] 1. **Prologue**

Great hopes are being placed on the ISDN as an important infrastructure for promoting social as well as economic activities. It is expected that the ISDN will replace the existing public telephone service network in the near future.

In Japan, domestic ISDN INS Net 64 was started by NTT in the spring of 1988; internationally, KDD started an ISDN service connecting Japan with the United Kingdom and the United States using the basic as well as primary access interfaces in June 1989. As for near-term developments in the ISDN, it is expected that NCC [new common carriers] will step up their ISDN-related activities, and that efforts to upgrade existing corporate information communications networks to ISDN-level networks will have made substantial progress in Japan by the 21st century.

With regard to the connection of terminals to the ISDN network, a completely new interface for use in the 2B+D ISDN channels has been made public. This move is expected to promote the development of such highly sophisticated terminals as digital telephones, moving-picture TV phones and handwritten information transmission devices. The availability of these terminals, coupled with sophisticated ISDN service functions, should make ISDN service more attractive.

Considering the importance of ISDN standardization for promoting the development of the network and terminal equipment, work on standardizing domestic ISDN is currently underway in Japan in compliance with CCITT recommendations.

In the following, I will describe the current situation of ISDN service in Japan 1 year after the start of the service and its future prospects from the viewpoint of a developer of terminal equipment.

2. Current State of ISDN Terminal Development

With the start of ISDN service, various kinds of terminal equipment began to appear in the domestic market. However, most of these were terminal adapters for connecting existing terminals to the ISDN network. The principal ISDN terminal equipment and devices developed during the past year will be introduced below.

1) Terminal Adapters

Most of the personal computers, office computers and data processing terminals that are currently in use cannot be connected to the ISDN network directly. As the R-point interface, V.24 and V.35 are popular as the V-series terminal and X.21 as the X-series interface. Terminal adapters are devices that enable existing computers, data terminals, telephones, G3 facsimile machines, modems and other equipment which have analog interfaces to be connected to the ISDN network in order to take advantage of the high communications speed, high reliability and economy of the ISDN.

Currently, a V.24 interface is used popularly in these adapters to connect personal computers to the ISDN network. In the future, demand for high-speed X.21 interface, which is used in high-speed G4 facsimile machines, will increase to take full advantage of the ISDN.

As for the line switching adapters, there are models containing the V.24, V.35 and X.21 interfaces, respectively. Concerning the adapters for packet switching, two types are currently available--one for existing nonpacket terminal equipment and one for packet terminal equipment.

The following table shows the specifications of these terminal adapters which are being produced by Fujitsu. Each of these devices has two ports for separate data terminal equipment connection so that the connected equipment can

Table. Specifications of Terminal Adapters Developed by Fujitsu

Adapter model		ISPT-A	ISPT-8	ISPT-C	ISPT-AP
Line for connection of adapter: INS Net 64/FETEX-3000 Series					
Connection mode: point-to-point, point-to-multipoint wiring					
Switching		Line switching	Line switching	Line switching	Line switching
Data	Interface	2 port/V.24	2 port/V.35	2 port/X.21	2 port/V.24
	Speed	synch/asynch up to 19.2 k	synchronized 48/56/64 k	synchronized up to 9.6 k, 48/64 k	synch/asynch up to 19.2 k
	Call procedure	manual/direct call AT command/V.25 bis	manual/ direct call	manual/ direct call X.21	manual AT command*
Telephone		Interface: 1 port, 2-line analog telephone Signal: DP (10 pps, 20 pps), PB			
Added-value service		Displaying addresser's number, telephone call charge, etc.			

*As for switching, direct call function and V.25 bis remote addressing function are included. As for packet switching, X.28 and X.25 are included.

take full advantage of the ISDN. In addition to a manual call function, these adapters have a direct call function for automatic addressing to a registered destination that is activated when the power switch is turned on, and a remote call function that is activated by entering the AT command or V.25 bis command from the keyboard of the data terminal connected to the adapter.

2) Digital Telephone

The ISDN makes it possible to offer telephone service with a higher voice quality than conventional telephone services, and information can be transmitted in a shorter time. Most of the digital telephones currently available have a data communication function by taking advantage of ISDN's 28 channels.

In addition, these telephones are capable of displaying the addresser's telephone number and the service charge and are capable of transferring a received call using the D channel. Telephones with these capabilities are beginning to be used in Japan in corporate TV conference systems.

The digital telephones with data communications capability have other capabilities in addition to the basic telephone functions of flashing the addresser's telephone number, the service charge and the total of other service-related charges, the function of refusing to let the telephone number be known and the capability for direct telephone communications. These telephones have the capability of implementing synchronous/asynchronous data communications with manual automatic addressing with a maximum bit rate of 19.2 kbps through the built-in V.24 interface.

3) ISDN Key Telephone

In the ISDN a single communications circuit can carry two B channel signals simultaneously. This means that the circuit has a capability equivalent to two separate communications circuits in conventional telephones.

In an ISDN key telephone, these two separate circuits are used for the additional purpose of realizing an in-house push-button extension telephone system for efficient utilization of the circuits. Demand for the B channels are beginning to come from both small businesses and multigeneration large families that had been using two separate telephone circuits.

4) Motion-Picture Color TV Telephone

The ISDN makes it possible to reduce the time required for the transmission of still image signals from a TV camera and to reproduce a moving picture in the terminal. Motion-picture color TV telephone service can be realized by transmitting compressed video signals and voice signals over one ISDN B channel.

The TV camera contains an 0.5-inch CCD chip as the image pickup element, while a 5-inch color LCD is used for picture reproduction. In the service, image information consisting of 96 x 60 pixels is transmitted at a speed of 7 frames per second over the ISDN channel. When using the TV telephone with the still-picture mode, the ISDN channel makes it possible to transmit 384 x 240 pixels to reproduce a higher quality picture.

5) Handwritten Information Transmitting Terminal

By taking advantage of the availability of the two ISDN channels, it is possible to transmit voice information and handwritten information simultaneously using a handwritten information transmission terminal. This terminal consists of an ordinary telephone function plus a 640 x 400 pixel plasma display, and it can transmit various kinds of handwritten information via the visual information inputting device in real time while the sender is talking with an appropriate party on the phone.

6) G4 Facsimile Machine

In facsimile communications, higher quality document transmission at greater speed can be realized using the ISDN. Using a G4 facsimile machine, documents can be transmitted with a better reproduction quality and more rapidly than is possible using a conventional G3 facsimile machine via the terminal adapter. With a further increase in demand for the new facsimile service, it is expected that it will become possible to connect the advanced machine directly to the ISDN network.

7) ISDN Connection Card for Personal Computer

Considering the capability of the ISDN, which makes it possible to achieve data communication and access to data bases via the public network at a higher speed, it is expected that such advantages will be used by an increasing number of private customers.

For their benefit, various IC cards that can be plugged into personal computers will become available. These will be used to connect the personal computers directly to the ISDN network. These cards would also have the additional functions of call management, host-to-host file transfer and other useful functions.

3. Future Prospects and Problems

The start of ISDN service is expected to promote the spread of digital communications and a further diversification of the means of data and information communications in Japan.

Spread of Digital Communications

The ISDN combines the high-speed capability of conventional private high-speed digital communications lines and the public nature of ordinary public communications networks.

Now that ISDN service has started, the digital communications service, which has been operated mainly in private lines leased to large corporate customers, will become more generally available.

For example, ISDN digital communications service has now become available to connect franchised store chains with many stores, which up to now have been unable to use the high-cost private digital communication lines. ISDN will also be useful for security services where the volume of communications traffic is small. In the near future, it will become easier for private individual customers to use the ISDN digital communications service.

Diversification of Communication Means

The start of ISDN service should encourage various ISDN-related developments on the network side as well as on the user side.

This will lead to further progress in the transmission of voice and image information as well as various kinds of data using computers and other terminal equipment connected to the ISDN network.

As an example of such diversified ISDN communications service, there is a merchandise ordering service in which a customer can place an order using a data communication function equipped digital telephone and a personal computer connected to the ISDN network. In this service, customer security can be strengthened by using the combination of the addresser's telephone number and a password that is transmitted using ISDN's D channel.

3.1 Interface

A number of problems concerning ISDN interface remain to be solved. These include coordination of transmission speeds, connections with existing domestic networks and connections with international networks.

(1) Coordination of Transmission Speed

At present there are three standardized speed coordination modes available in Japan—X.30 for the X series and V.110 and V.120 for the V series. The features of these modes are described in the table below. Compared with V.120, X.30 and V.110 have better overall performance. Because of this, the two coordination modes are already used in some ISDN products.

So far, good compatibility in connections between the same interface mode has been ascertained through mutual connection tests conducted in accordance with TTC standards. To popularize the ISDN further it is vital to develop common functions for effecting connections between different interface modes.

As for V.120, studies are underway on how to achieve further improvements in relation to the frame relay, and the relay scheme has the possibility of replacing the current B/D channel packet service as a higher-speed data communication method. In the United States, study of the V.120 interface is more advanced, and considering this it is necessary for Japan to continue paying close attention to developments in America, including the movement of ANSI.

Meanwhile, efforts to promote the unification of formats above the layer 4, including applications, at the OSI model level must be stepped up.

Table 1.

<table>
<tr><th colspan="2">Speed coordination modes</th><th>Features</th></tr>
<tr><td>X series</td><td rowspan="2">X.30/
V.110</td><td rowspan="2">Speed coordination by bit mapping scheme
<Advantages>
•Real time
•Easier multiplexing
•Possible to realize through hardware means (4,000 to 5,000 gates
•Already being used in practical applications
•Compatibility with V.110
<Disadvantages>
•Need for implementing error control between DTEs
•Need for inband parameter exchange and for further evaluation of the performance of network-independent clock</td></tr>
<tr><td rowspan="2">V series</td></tr>
<tr><td>V.120</td><td>Speed coordination by HDLC flat stack scheme
<Advantages>
•Error controlling by LAPD function
•Statistical multiplexing
•Possibility of developing to frame relay [application]
<Disadvantages>
•Delay produced in assembling and disassembling HDLC frame</td></tr>
</table>

(2) Connection With Existing Networks

The ISDN network's connections with the existing public communications networks and the DDX-P packet switching service network have already been realized.

Line switching is more suitable for transmitting a large volume of high-speed data at a comparatively low cost, while ISDN's B/D channel packet-switching service, including the switching service via DDX-P, is more suitable for transmitting a relatively small volume of data by occupying the communications line for a fairly long period of time, as in the case of communications between personal computer terminals. The D channel has a slower packet switching speed than the B channels, but it has the advantage of being capable of transmitting data in multiplexed form. Users can make a choice between these two in accordance with their needs.

In line-switching service, currently there is no means of mutual connection between computer-to-computer data communications lines via the public telephone network and the corresponding line via the ISDN network. To make the connection possible, it is necessary to develop new modems capable of effecting the connection between the two networks.

(3) Connection With International Network

In June 1989, KDD started an international ISDN service connecting Japan with the United States and the United Kingdom through the basic access interface as well as the primary access interface. This service supports the connection of the 56 kbps American Accunet to the international network. The connection is made through V.110 interface for communication speed coordination.

As for HLC and LLC information transmission, terminal-to-terminal transfers will become possible in 1990 when the No 7 ISUP signal mode is introduced for communications between international terminal points.

3.2 Terminal

In this section I will refer to the development of multifunction ISDN terminal equipment, the introduction of LSI technologies for the development of more compact ISDN interface and the ISDN standardization effort.

(1) Multifunction ISDN Terminal

With the integration of ISDN interfaces, it will become possible to connect many kinds of terminal equipment including conventional telephones, facsimile machines, personal computers and telex to the same terminal socket.

This will lead to the appearance of a piece of a terminal equipment that will combine the functions of these kinds of terminal equipment in the future. The effort to develop such a terminal must do more than simply combine the functions of existing equipment; it must lead to the generation of a new service using the newly developed terminal. In the following, I will briefly describe the multifunction terminal, media conversion and man-machine interface.

Multifunction

There is a possibility that a new service can be generated by combining the individual functions of conventional terminal machines.

For example, by combining the function of a telephone with that of a personal computer, it will become possible to manage the telephone call record, the service-related charges and telephone numbers.

Media Conversion

Using a new terminal that combines the functions of a number of separate conventional pieces of terminal equipment, it will become possible to generate a new service by mutual conversions of the voice signals, image signals and data signals involved in each of these pieces of equipment.

For example, it will become possible to display received facsimile signals on a computer screen for editing by converting them into a computer-acceptable form. It will also become possible to convert the signals received through computer communications into voice using a multifunction terminal.

Man-Machine Interface

In general, unification of the functions of conventional terminal equipment would make the resulting multifunction equipment more complicated to operate for ordinary users. This makes it more important to develop a better man-machine interface.

An improved interface will be necessary to enable ordinary users to perform such jobs as data communications, information retrieval from their host computers and facsimile communications as easily as they can manipulate the document files within their respective terminals.

The development of multifunction terminal equipment must be accompanied by efforts to make the equipment easier to use.

(2) Introduction of LSI Technologies

The ISDN involves the use of a large-scale interface in terms of both hardware and software. Improvements must be made in two areas.

First, the time required for the development of a new interface must be cut further to meet the demands of the market promptly. Second, efforts must be made to develop less costly terminal equipment.

To help promote their realization, LSI technologies must be introduced into the ISDN interface, and the modular scheme must be pushed in the development of the software. This will make the interface smaller in scale and make it possible to develop a less costly interface within a shorter time. These developments will in turn make it easier for those newcomer ISDN product makers to develop the terminal equipment, and this, in turn, would lead to a further popularization of the ISDN.

(3) Standardization

In Japan, the development of ISDN terminal equipment has been promoted in accordance with CCITT recommendations and TTC standards. The ISDN is still in its infancy, and the country must keep paying close attention to standardization efforts. For the purpose of promoting compliance with these recommendations and standards, relevant documents are being published in Japan.

To achieve a further enhancement of the functions in an ISDN network it is necessary for the terminal equipment to have a more flexible design. These pieces of equipment must have the ability to continue their normal functions even if an upgrade is made in the network. They also are required to be designed so that an expanded function to accommodate a network function improvement can easily be added.

(4) Other

Other factors that must be considered include the streamlining of operability between conventional telephones and ISDN telephones, and the introduction of four-line wiring in a user's premises.

4. Epilogue

In this chapter, I have described the kinds of ISDN terminal equipment needed for the further development of the information-oriented society and the features of several ISDN interfaces. In order to develop the ISDN into an attractive communications service, it is important for the domestic industry and users—including equipment makers, schools, regional communities, service industries and citizens—to actively participate in the effort to formulate the vision for the future information society.

In the coming years, the ISDN network will be expanded further, more terminal equipment will be used popularly, the standardization of the ISDN will progress further and the expansion of ISDN's service area in Japan is expected to continue. Under these circumstances, the building of in-house ISDN networks by the country's corporations will accelerate. This will generate a large growth in demand for more public and other communication lines.

A further expansion of these communication lines will lead to an increase in the number of subscribers, and the resulting increase in demand for the terminal equipment will encourage the appearance of more inexpensive terminal adapters and ISDN terminal equipment in the market. This will encourage demand for such highly sophisticated terminals as TV telephones and multifunction terminals, which can take advantage of the merits of the ISDN.

We as a maker of such terminal equipment intend to continue our efforts to grasp the needs of users, to develop more user-friendly terminal equipment, to develop a new service and to promote the standardization of the ISDN.

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Moving Images and ISDN

906C3825 Tokyo HEISEI GANNEN DENKI JOHO KANREN GAKKAI RENGO TAIKAI (1989 Joint Convention Record of Institutes of Electrical and Information Engineers) in Japanese Vol 4, 5-7 Sep 89 pp 61-64

[Article by Masami Murakami, KDD's Kamifukuoka Research Institute]

[Text] **1. Prologue**

ISDN service started in Japan in 1988, and in 1989 23B+D (1.5 Mbps) channels were added to the existing ISDN network. Now that the ISDN is being operated at a maximum bit rate of 1.5 Mbps, it is expected that an increasingly diversified ISDN service will become available. Internationally, a 2B+D channel service connecting Japan with the United States and the United Kingdom with a maximum bit rate of 2 Mbps was started in 1989. It is expected that the international ISDN network will be expanded to include other countries in the coming years.

Under these circumstances, a number of countries are exploring possible application fields for the ISDN. It is believed that the current narrow bandwidth ISDN with a maximum bit rate of 1.5 Mbps could deliver comparatively satisfactory results in high-speed data communications, G4 facsimile transmission, TV conferencing and TV telephone service. In the projected wide bandwidth ISDN with the bit rate of around 150 Mbps, it should become possible to transmit high-definition TV (HDTV) and conventional TV broadcast signals involving moving image information. In the following, I will describe the current state of the technology for the transmission of moving image signals and the problems involved.

2. ISDN Bit Rates and Image Signal Transmission

Table 1 shows the hierarchy of the ISDN bit rates defined in the CCITT recommendations with 64 kbps as the base rate. Table 2 shows the bit rates considered to be appropriate for use in the transmission of image signals in the listed fields of application. For example, 64 kbps is considered enough for TV telephone service and the H_0 channel's 384 kbps is appropriate for use in TV conference service in terms of cost. The bit rates in B ISDN's H_2 channel would be appropriate for use in TV broadcasting applications. In the European countries, bit rates of 70 Mbps or 140 Mbps are expected to be adopted for TV broadcast applications for the transmission of program materials and program distribution.

For HDTV application, 140 Mbps is expected to be adopted. Currently, the development of digital technologies including efficient coding of HDTV signals for use in the TV is underway in many countries.

Table 1. ISDN Transmission Bit Rates

H_0	384 kbps	
H_1	H_{11}: 1536 kbps	H_{12}: 1920 kbps
H_2	H_{21}: 30.720 Mbps H_{22}: 33.792 Mbps H_{23}: 44.160 Mbps	
H_3	H_3, H_4 under study	$H_3 \simeq 70$ Mbps $H_4 \simeq 140$ Mbps

Table 2. Bit Rates Needed for Image Signal Transmission in Various Fields of Application

Category of image signal transmission service		Transmission bit rate
HDTV		100 Mbps or more
TV broadcasting	Program material transmission Program distribution	45~140 Mbps 30~45 Mbps
SNG (news program)		6~20 Mbps
TV conference		384 kbps~2 Mbps
TV telephone		48~64 kbps

3. Image Signal Transmission Technology

In order to digitalize composite analog TV signals, the sampling frequency must be around 10 MHz and a quantization accuracy of 8 bits pixel must be ensured. This means that the base bit rate required for the transmission of the TV signals must be about 80 Mbps. In transmitting the component signal, the bit rate goes up to around 120 Mbps. This means that the base bit rate of a TV conference system using a rate of 384 kbps is from 1/240 to 1/360 of the bit rate required to handle ordinary TV signals, and in TV telephone service the base bit rate is required to be reduced to 1/1500 to 1/2000. In TV conference and TV telephone service, a degradation of the picture quality due to lower bit rates can be tolerated to a certain degree to keep operational costs as low as possible. However, in TV broadcasting the bit rate reduction must be made without causing a perceptible degradation in the quality of reproduced TV pictures. For example, in the CCIR-defined 4:2:2 signal the base bit rate of 216 Mbps has to be slashed to 1/5 to 1/7 in the end.

This is why the development of a highly efficient coding technology is vital. At present, the development of coding technologies for application to TV broadcasting, TV conferencing and TV telephone service is in the final stage. Table 3 lists the typical TV broadcast coding schemes developed thus far, and Table 4 lists the schemes for TV telephone service. In the ISDN, international

Table 3. Typical TV Broadcast Coding Schemes Developed to Date

CODEC Parameters	A (9)	B (8)	C (7)	D (6)	E (5)	F (4)
Input signal type	Component	Component	Component	PAL	PAL	NTSC
Sampling frequency	4:2:2	12 MHz	4:2:2	13.31 MHz	17.7 MHz (4 fsc)	10.7 MHz (3 fsc)
Transmission bit rate (Mbps)	140	34	30	68	34	30
Coding algorithm	•Intra-field DPCM •63-level quantizer	•Intrafield DPCM •31-level quantizer •Fix word length •Sub-sampling	•Motion compensated interframe/ interfield/ intrafield adaptive DPCM •Adaptive quantizer •Variable length coding	•Intra-field adaptive DPCM •Adaptive quantizer •Variable length coding	•Intra/ interfield DPCM with 14 picture elements •1/2 sub-sampling •22-level quantizer	•Intra/ interfield adaptive DPCM •Adaptive quantizer •Variable length coding
FEC	None	Included	(239, 255) BCH	(239, 255) BCH	None	(239, 255) BCH

Table 4. Typical TV Telephone Coding Schemes Developed to Date

CODEC	Color mode	Resolution (Ver./Hor.)	Frame number	Transmission rate (kbps)	Feature of coding scheme
Windcom VTC-56	Color	256/256	Up to 10	56	Unit block condition Image compensation + DCT
Pictel C-2000	Color	256/256	Up to 15	56	Motion compensated DC-AC conversion
KDD Invite 64	Color	128/120	Up to 10 (at 64 kbps)	56/64 (Including voice)	Motion compensated +Y/C vector difference quantization
NTT	Color	384/240	Up to 15	64-128	Motion compensated + vector quantization
Mitsubishi MVC-6300	Color	336/240	Up to 6 (at 64 kbps)	56/64-384	Motion compensated Interframe vector quantization
Finland VTT VINE-64	Monochrome Monochrome	Video bandwidth: 1.2 MHz	12.5	64	Interframe DPCM

standardization of the service is particularly important to reduce transmission costs without sacrificing the quality of transmitted signals.

To date, the international standardization of highly efficient coding schemes for TV broadcasting has been promoted in compliance with the CDCIR SG11 and CMTT formats, and for TV conferencing and TV telephone service with the CCITT SGXV format. The standardization work is now in the final stage. In the following, I will elaborate on these formats.[1,2]

3.1 Coding Schemes for TV Conferencing and TV Telephone Service

CCITT SGXV has been endeavoring to achieve an international standardization based on a PCM hierarchy 1.5/2 Mbps coding scheme and a 384 kbps coding scheme. Recently, its groups of experts have started preparations for recommending px64 kbps (p = 1...30) as the standard coding scheme for application to the ISDN in the July 1990 SGXV meeting.

Table 5 shows the basic specifications of the px64 kbps coding scheme, including the image format and coding algorithm, which have been tentatively agreed upon. One of the major achievements of the standardization efforts was the adoption of the Common Intermediate Format (CIF). This format is aimed at overcoming the problems resulting from the existence of different television broadcasting modes around the world by simplifying the signal conversion process as much as possible. The format calls for coding these different TV signal modes with a common algorithm after the 525/60 (NTSC) group signal and 625/50 (PAL, SECAM) group signal were converted into a common intermediate video format.

Table 5. Basic Specifications of px64 kbps Coding Scheme

Item		Description
Input signal	Format	Y, C_B and C_R in CIF (360 pixels x 288 lines x 29.9 MHz, noninterlace)
	Image for coding	CIF / QCIF Y: 352(H)x288(V) / 176(H)x144(V) C_B,C_R: 176(H)x144(V) / 88(H)x772(V) option / must
Coding	Algorithm	Interframe prediction + DCT hybrid coding
	Motion compensation	Optional
	DCT	8 x 8
Error correction code		(511, 493) BCH

3.2 TV Broadcast Signal Coding Scheme

The work on standardizing a TV broadcast signal coding scheme is being pushed jointly by CMTT and SG11. The work for the development of the coding scheme is assumed by CMTT's interim technical group IWP CMTT/2, and the work for the evaluation of whether or not the developed coding scheme satisfies the picture quality requirement for TV broadcasting is being undertaken by SG11's interim group IWP11/7.

Table 6. Proposed TV Signal Coding Schemes Under Evaluation

<table>
<tr><th colspan="2" rowspan="2">ISDN
Parameter</th><th colspan="2">H_2</th><th rowspan="2">H_4</th></tr>
<tr><th>System A</th><th>System B</th></tr>
<tr><td colspan="2">Video input/output</td><td colspan="3">4:2:2 signals, Rec. 601</td></tr>
<tr><td rowspan="3">Preprocessing</td><td>Blanking</td><td colspan="3">Removal of vertical and horizontal synchronized signal</td></tr>
<tr><td>Subsampling</td><td colspan="3">None</td></tr>
<tr><td>Prefilter</td><td colspan="3">None</td></tr>
<tr><td rowspan="6">Coding algorithm</td><td>Motion compensation</td><td>Per unit block</td><td>Per 1 block/field</td><td>None</td></tr>
<tr><td>Coding</td><td colspan="2">Motion compensated interframe/interfield/intrafield</td><td>Intrafield</td></tr>
<tr><td>Adaptive control</td><td>Per 12 unit pixel</td><td>Per unit of 8 line/8 pixel</td><td>None</td></tr>
<tr><td>DCT</td><td>None</td><td>Two-dimensional DCT</td><td>None</td></tr>
<tr><td>Quantization</td><td colspan="2">Controlling based on buffer memory accumulation level</td><td>Folded quantizer, 6 bit/pel</td></tr>
<tr><td>Variable length coding</td><td>1-12 word length</td><td>2-18 word length</td><td>None</td></tr>
<tr><td colspan="2">Buffer memory</td><td>1.5 Mbit</td><td>1 Mbit</td><td>Negligibly small</td></tr>
<tr><td colspan="2">Error correction code</td><td colspan="2">(239, 255) BCH</td><td>(27,29) Reed-Solomon</td></tr>
<tr><td colspan="2">Voice</td><td colspan="2">Up to 1536 kbit/s</td><td>2,048 kbit/s</td></tr>
</table>

As for the broadcast signal coding, new schemes have been put forth by a number of countries. These include the motion compensated interframe/interfield/intrafield adaptive DPCM, interframe/intrafield adaptive DPCM and intrafield DCT. The experts group has been evaluating these schemes for unification or further improvement of the characteristics. Now the work by the group is in the final stage. As for the H_2 channel adaptation, an international-scale hardware experiment for the evaluation of picture quality is being conducted to decide which of two schemes—the motion compensated interframe/interfield/intrafield adaptive DPCM (System A) or a hybrid scheme (System B) combining the System A with DCT—to adopt. Either of the schemes is capable of attaining the required broadcast picture quality with bit rates of 45 Mbps (H_{23}) as well as 32-34 Mbps (H_{22}). As for the H_4 channel adaptation, at first the interfield prediction scheme and the color signal subline scheme were proposed, but now it is expected that the two-dimensional intrafield prediction scheme, which requires no adaptive processing technology, will be adopted. Table 6 shows the basic specifications of these candidate coding schemes.

3.3 HDTV Coding Scheme

HDTV requires a bandwidth five times greater than that of the standard TV broadcast, and in PCM it calls for a bit rate around 600 Mbps. To make it possible to transmit signals at such a high bit rate, there is a plan for the establishment of a 120 Mbps channel via a 72 MHz Intelsat satellite repeater and a submarine fiber optic communications channel capable of handling bit rates ranging from 120~140 Mbps.

For transmission using these channels the bit rate of HDTV signals must be slashed further. The technology for cutting the rate is based on digital signal transmission technology, which combines the scheme of interframe/ interfield prediction and intrafield prediction. The sampling frequency is 13.5 MHz for standard TV broadcasts as compared to 74.25 MHz for HDTV. Considering this high sampling frequency, the coding scheme for application to HDTV must be capable of carrying out the job effectively with a significantly shorter coding-processing time. Table 7 lists the features of the HDTV signal coding schemes that have been introduced into the experimental models of hardware for evaluation.[13-16]

Table 7. Highly Efficient Coding Schemes for HDTV Application*

Coding scheme	Intrafield DPCM coding	Intrafield DPCM coding	Interframe/intrafield predictive coding	Interframe/intrafield predictive coding
Signal type	HLO-PAL (30 MHx)	$Y/C_W/C_N$ (20.7.55 Hx)	$Y/C_W/C_N$ (20.7.55 Hx)	$Y/C_W/C_N$ (20.7.55 Hx)
Sampling frequency	61 MHx	Y-48 MHx C-16 MHx	Y-48 MHx C-16 MHx	Y-48 MHx C-16 MHx
Preprocessing	—	Halving pixels by line offset subsampling	•Noise removal by a filter •TDM	•Noise removal by a filter •TDM
Coding algorithm	•Value prediction by sampling pulses ahead •6.5 bit fixed length coding	•Value prediction •7 bit fixed length coding •Reflected quantization •Noise filter	•Interframe extraporation/intrafield extraporation adaptive prediction (per unit pixel) •Variable length coding • Scalar quantization	•Interframe extraporation/intrafield extraporation adaptive prediction (per unit block) •Variable length coding •Vector/scalar quantization
Bit rate	400 Mbps	120/140Mbps	100/140 Mbps	**44/100/140 Mbps

*Experimental hardware has been fabricated or is being fabricated for evaluation of the listed coding schemes.
**For audio-visual explanation media application.

Japan is currently the only country in the world where HDTV coding hardware is being developed.

The European countries also have a great interest in the development of this coding technology. Although they have yet to translate the technology into hardware, these countries have developed a bit rate reduction technology for use in the digital signal transmission in HDMAC, the European version of HDTV. This reduction technology employs a PCM/DPCP hybrid scheme for the H_4 channel. In DPCM the possibility of using the extraporation prediction scheme combined with the 64-level folded quantification of DPCM signals is under study.

4. Problems To Be Solved

It is said that now is the era of video culture. TV broadcasting service via satellite has commenced in Japan, and programs are being broadcast around the clock. Further, the development of technologies and other preparation work have been made for the start of so-called new media services, including still-picture TV telephone service and HDTV broadcasts.

During the past 2 years or so, remarkable progress has been made internationally toward the start of a full-fledged higher-quality image information transmission business, based on the progress in digitalization of communications networks and the ISDN. Digitalization has made it possible to realize TV telephones and TV conferencing services as the foundation of the business. Currently, various noncarrier organizations have joined the carriers in new media-related research and development efforts. To promote the popularization of TV telephones and TV conferencing services, the following two problems must be solved: 1) further improvements in image signal coding technology for the transmission of signals at a rate of 64 kbps, and 2) the development of less expensive coding hardware.

As for the problem of coding technology, the adoption of the vector quantization scheme, in addition to an improvement of the characteristics of motion compensated interframe DCT, could help reproduce a higher quality picture. In addition, a further improvement could be made by introducing an intelligent coding scheme, as a new coding concept. Current 64 kbps TV telephones have poor spacial resolution and poor picture quality due to the low frame rates, which range from 12 to 15 per second. When a TV telephone deals with only a human image, it is relatively easy to introduce intelligent coding technology for the reproduction of a higher quality picture.

The international adoption of a px64 kbps coding scheme would accelerate the introduction of LSI technologies into hardware, and this would in turn promote the streamlining of hardware specifications among different equipment makers. At the same time, a further expansion of ISDN public communications networks will help popularize the service together with the availability of less costly service rates and equipment.

Currently, studies are being made concerning the introduction of asynchronous transmission mode (ATM) for the transmission of coded image signals. It is important to quantify the degree of improvement in the transmission when this mode is used as compared to conventional transmission modes.

5. Epilogue

Further progress in the ISDN will generate various image transmission services in the coming years. The fact that ISDN service rates have been set at nearly the same levels with the corresponding rates for conventional digital transmission services in Japan will help popularize TV telephone and TV conferencing services for use not only by corporate customers, but also by private customers. It is important to continue paying close attention to the effects these two-way image transmission services would have on society and the developments in HDTV and TV broadcast technology vis-a-vis communications technology.

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